The Relationship between Human Semen Parameters and Environmental Exposure to Polychlorinated Biphenyls and *p,p′*-DDE

Russ Hauser,[1,2] Zuying Chen,[2] Lucille Pothier,[1] Louise Ryan,[3] and Larisa Altshul[4]

[1]Department of Environmental Health, Occupational Health Program, Harvard School of Public Health, Boston, Massachusetts, USA; [2]Vincent Memorial Obstetrics and Gynecology Service, Andrology Laboratory and In Vitro Fertilization Unit, Massachusetts General Hospital, Boston, Massachusetts, USA; [3]Department of Biostatistics, and [4]Department of Environmental Health and Environmental Science and Engineering Program, Harvard School of Public Health, Boston, Massachusetts, USA

Scientific and public concern exists about potential reproductive health effects of persistent chlorinated organic chemicals, such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and dichlorodiphenyldichloroethylene (DDE, the most stable daughter compound of DDT). To explore the hypothesis that environmental exposures to PCBs and DDE are associated with altered semen parameters, we conducted a cross-sectional study of 212 male partners of subfertile couples who presented to the Massachusetts General Hospital Andrology Laboratory. Semen parameters were analyzed as both a continuous measure and dichotomized based on World Health Organization reference values for sperm concentration (< 20 million/mL), motility (< 50% motile), and Kruger strict criteria for morphology (< 4% normal). The comparison group for the dichotomized analysis was men with all three semen parameters above the reference values. In serum, 57 PCB congeners and *p,p′*-DDE were measured by congener-specific analysis using gas chromatography with electron capture detection. There were dose–response relationships among PCB-138 and sperm motility (odds ratio per tertile, adjusted for age, abstinence, and smoking, and *p*-value for trend were, respectively, 1.00, 1.68, 2.35, and *p*-value = 0.03) and morphology (1.00, 1.36, 2.53, *p*-value = 0.04). There was limited evidence of an inverse relationship between sum of PCBs, as well as those PCBs classified as cytochrome P450 enzyme inducers, with sperm motility and sperm morphology, as well as limited evidence of an inverse association between *p,p′*-DDE and sperm motility. The lack of a consistent relationship among semen parameters and other individual PCB congeners and groupings of congeners may indicate a difference in spermatotoxicity between congeners. *Key words:* DDT, environmental health, polychlorinated biphenyls, reproductive health, semen, sperm. *Environ Health Perspect* 111:1505–1511 (2003). doi:10.1289/ehp.6175 available via *http://dx.doi.org/* [Online 19 May 2003]

Currently scientific and public concern exists about persistent organic chemicals, such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and dichlorodiphenyldichloroethylene (DDE, the most stable daughter compound of DDT). Several researchers have hypothesized that these compounds may be associated with the suggested, although not confirmed, downward trend in semen parameters (Irvine et al. 1996; Sharpe and Skakkebaek 1993). The concern stems from studies showing that PCBs and *p,p′*-DDE are found in a large proportion of the general population (CDC 2003; Longnecker et al. 1997; Murphy and Harvey 1985; Stehr-Green 1989) and from animal and limited human studies suggesting possible associations of exposure to PCBs and *p,p′*-DDE with semen abnormalities (Bush et al. 1986; Dallinga et al. 2002; Richthoff et al. 2003). Serum levels of PCBs and *p,p′*-DDE are an integrated measure of internal dose, reflecting exposure from all sources over the previous years; depending on congener type, the half-lives of PCBs in the blood range from 1 to 10 or more years, whereas *p,p′*-DDE has a half-life of 10 or more years (Brown 1994; Phillips et al. 1989b).

PCBs and *p,p′*-DDE are persistent lipophilic chemicals. DDT was widely used as an insecticide, whereas PCBs were used in cutting oils and lubricants and as electrical insulators. Although their use and manufacture were banned nearly 30 years ago, they are ubiquitous and persist in the environment. They are distributed worldwide as environmental pollutants and have been measured in air, water, aquatic and marine sediments, fish, and wildlife (De Voogt and Brinkman 1989). Furthermore, they are biologically concentrated and stored in human adipose tissue. The general population continues to be exposed to PCBs and *p,p′*-DDE through ingestion of contaminated foods (fish, meat, eggs, and dairy products) and water, as well as through dermal contact (soil and house dust) and inhalation (indoor air in buildings that have various sources, as well as outdoor air).

Studies suggest that there is a temporal downward trend in human semen quality (Auger et al. 1995; Carlsen et al. 1992; Giwercman et al. 1993; Irvine et al. 1996; Swan et al. 1997, 2000). However, other studies suggest that semen quality has not declined or may have even increased marginally (Bujan et al. 1996; Fisch et al. 1996; Paulsen et al. 1996; Sherins 1995). Nevertheless, most of these studies suggest that semen quality varies by geographic location (Fisch and Goluboff 1996). It has been hypothesized that the geographic variation in semen quality may be caused by environmental exposures, lifestyle factors, or some unknown cause(s) (Fisch and Goluboff 1996). However, the temporal trend studies lacked information at the individual level on lifestyle factors, such as cigarette smoking, as well as information on exposure to potential environmental contaminants, such as PCBs and DDT (Sun et al. 1996; Vine et al. 1994).

To determine whether environmental levels of PCBs and *p,p′*-DDE are associated with altered semen parameters in adult men, we selected a study population without specific exposure to these compounds. Detecting even an association of small magnitude may have large public health significance because of the widespread distribution of PCBs and *p,p′*-DDE in the general population.

Materials and Methods

Subjects. The study was approved by the Harvard School of Public Health and Massachusetts General Hospital (MGH) Human Subjects Committees, and all subjects signed an informed consent. Subjects were male partners of subfertile couples who presented to the Vincent Burnham Andrology Laboratory at MGH between January 2000 and October 2001 for semen analysis. Individual men may or may not have been infertile. Sixty-six percent of eligible men between 20 and 54 years old agreed to participate. Men presenting for postvasectomy semen analysis and men receiving treatment for infertility, such as hormonal treatments, were excluded. Height and weight were measured, and a questionnaire was used to collect information on medical history and lifestyle factors.

Address correspondence to R. Hauser, Department of Environmental Health, Harvard School of Public Health, Bldg 1, Rm 1405, 665 Huntington Ave, Boston, MA 02115 USA. Telephone: (617) 432-3326. Fax: (617) 432-0219. E-mail: rhauser@hohp.harvard.edu

We thank I. Schiff, T. Toth, K. Isaacson, J. Shifren, and L. Godfrey-Bailey; R. Stolyar and S. Forsberg for the chemical analyses; and A. Trisini for assistance with manuscript preparation.

This study was supported by grants ES09718 and ES00002 from the National Institute of Environmental Health Sciences.

The authors declare they have no conflict of interest.

Received 24 December 2002; accepted 19 May 2003.